Data, Observation & Modelling

Thu. Nov 12, 2026 4:00 PM - 5:30 PM JST | Thu. Nov 12, 2026 7:00 AM - 8:30 AM UTC | Room A (Oshidori) (2F)

Oral A3 Data-Driven Emulators

Chair: Alain Arnaud, Deanesh Ramsewak

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[hyhteQZr-01] A Differentiable, Performance-Portable, Multi-Fidelity Computational Framework for Digital Twins of the Ocean

*Patrick Heimbach (1. University of Texas at Austin (USA))

We present an integrated computational framework for building digital twins of the ocean around a single differentiable modeling core. The core supports several coupled modes of operation: high-resolution, high-fidelity simulations that resolve ocean dynamics explicitly and low-resolution, parameterized models in which unresolved processes are represented by learned closures, implemented as neural operators trained online against the high-fidelity solutions. Because the hybrid data assimilation-machine learning framework is differentiable, these parameterizations are learned end-to-end and updated concurrently with the simulations they inform, allowing the coarse model to inherit dynamical consistency from its high-fidelity counterpart without a separate offline calibration stage. The framework is complemented by computationally efficient emulators trained on the high-fidelity model to further accelerate ensemble generation, uncertainty quantification, and scenario exploration (WHAT-IF experiments).

All components, the high-fidelity and parameterized simulation models, the online-trained neural operators, and the Sobolev-trained emulators, are automatically differentiable end-to-end and portable across heterogeneous HPC hardware, including GPUs, CPUs, and TPUs, using automatic compiler transpilation tools. This design allows a single codebase to move fluidly between resolutions and fidelities and to run efficiently across the diverse compute architectures found in modern, AI-puposed HPC and cloud environments. It is making accessible a vast range of compute systems and providing an efficient path toward operational, sensitivity-informed, data-driven digital twins of the ocean.

© 2026 DITTO Summit Local Organising Committee. All rights reserved.